Trends in Fish Tissue PCB Concentrations in the Little Mississinewa and Mississinewa Rivers from 1984 to 2013 with Implications on Fish Consumption Advisories and Designated Beneficial Aquatic Life Uses.

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Introduction

The Mississinewa River watershed (Hydrologic Unit Code 05120103) currently has human health and wildlife designated beneficial use impairments for polychlorinated biphenyls (PCBs) (IDEM 2014) along the main stem Mississinewa River and along the Little Mississinewa River. The Little Mississinewa River is listed as a NO FISH CONSUMPTION waterway and the Mississinewa River is listed for limited fish consumption due to PCBs (ISDH 2015). PCBs are part of a group of man-made organic chemicals known as chlorinated hydrocarbons and were manufactured from 1929 to 1979. They were often used in transformers and capacitors, oils, inks, paints, plastics, floor finish, adhesives, and electrical equipment. PCB production and use in the United States were banned in 1979 (U.S. Environmental Protection Agency (U.S. EPA) 1992a). PCBs are long lived in the environment and slow to breakdown. Due to the persistence of PCBs in the environment, they are still detected in the fish from the Little Mississinewa and Mississinewa rivers decades after the contamination occurred. PCBs sorb to sediments and are relatively water-insoluble and lipophilic (Riva-Murray and others, 2003). PCBs are considered toxic, carcinogenic and mutagenic (Eisler 1986; Colborn et al. 1993), and have been implicated in endocrine disruption of fish and wildlife (Colburn et al. 1993; U.S. Environmental Protection Agency 1997). Once in the environment, PCBs persist for long periods of time as they are not readily broken down. PCBs readily accumulate in the tissue and organs of fish, many of which, in turn, are consumed by birds, mammals, and predatory fishes (Riva-Murray et al. 2003). The greatest human risk of exposure to PCBs is through the consumption of contaminated fish (Johnson et. al. 1999; Mahaffey et. al. 2004; McDowell et. al. 2004).

PCBs were released to the Little Mississinewa River directly through outfalls coming from the responsible parties and indirectly after processing at the Union City Wastewater Treatment Plant (WWTP) (U.S. EPA, 2005). The PCBs could have entered the streams through the Union City wastewater treatment system at any time over a period of decades prior to the discovery in 1984 (Winchester News Gazette 1985). In 1984, the Union City WWTP was in the process of upgrading its treatment facility when 80,000 gallons of PCB contaminated sludge was discovered in the holding tanks (Haney 1986). Union City applied for federal funding to remove the contaminated sludge and complete the upgrade to the WWTP, however funding from U.S. EPA would only be awarded if the PCB source could not be identified. At that time, the Indiana State Board of Health (ISBH) sampled sediment and fish tissue to determine any effects of the WWTP effluent on the Little Mississinewa River. Two sites were sampled on the Little

Mississinewa River and one site was sampled on the Mississinewa River downstream of the confluence with the Little Mississinewa River (Haney 1986). The PCB concentrations in all of the fish tissue samples collected and analyzed exceeded the United States Food and Drug Administration (FDA) Tolerance Level for PCBs (2.0 ppm) (21CFR109.30 (a) (7), 2015). Results from the 1984 study concluded that it was likely that fish from the entire Little Mississinewa River (approximately 11 miles) exceeded the FDA Tolerance limit for PCBs. Fish collected from the Mississinewa River one half mile downstream of the confluence with the Mississinewa River also exceeded the limit. However, the extent of the PCB impairment along the Mississinewa River remained unknown along with the source of the contamination. In 1985, the ISBH sampled the Little Mississinewa River with the goal of identifying the source of high PCB concentrations in the sediments. Additionally, ISBH issued a Fish Consumption Advisory against consuming all types of fish from the Little Mississinewa River near Union City, as well as the Mississinewa River (IDEM 1986). Based on this study, the Viacom facility (formerly Westinghouse, a small engine manufacturer), located along the Little Mississinewa River in Union City, Indiana was determined to be the PCB source (IDEM, 1988). In 1988, the Indiana Department of Environmental Management (IDEM), Office of Water Quality (OWQ) conducted extensive sediment and fish tissue sampling from the Little Mississinewa and Mississinewa rivers to determine the extent of PCB contamination in these waterways. In 1990, IDEM, OWQ began evaluating the Viacom facility through the U.S. EPA site assessment program for potential listing on the National Priorities List. In 1996, IDEM also began investigating the United Technologies Automotive Systems, Inc. (UTAS) facility (formerly Sheller Globe, a plating facility that manufactured small motors and currently known as Lear Corporation Automotive Systems). Results of the UTAS investigation indicated elevated levels of PCBs in the soil and sediments in nearby areas, including the Little Mississinewa River and Harter Park in Union City (U.S. EPA, 2010). To date, UTAS and Viacom have been identified as the only potentially responsible parties. Both the former Westinghouse and UTAS used hydraulic systems in their manufacturing processes that contained PCBs (U.S. EPA 2001).

For several decades PCBs were released to the Little Mississinewa River directly through outfalls for the facilities and indirectly after processing at the Union City WWTP. In 2001, USEPA completed removal actions at Harter Park and the Union City Cemetery. This removal activity resulted in approximately 58,000 tons of sediments and soils being moved to an off-site disposal location, restoring the properties to full use (U.S. EPA 2010). In 2002, the remedial investigation (U.S. EPA 2010) was completed at the UTAS and Westinghouse facilities. Following the initial investigation, remedial actions at both the Westinghouse and UTAS facilities were conducted from 2005 through 2009, resulting in a total of 100,035 tons of contaminated soils and sediments being excavated and 1,088,500 gallons of remedial action generated liquid waste being treated and discharged back to the river at the site (U.S. EPA 2010). The chronologies of the site events are included in Table 1. The remedial work is listed in Table 2.

Table 1. Chronology of site events in the Little Mississinewa River (LMR) (U.S. EPA, 2010)

Events	Year
LMR Sediment and Floodplain Investigations	1997
LMR Outfall Area-LMR Sampling and Interim Removal Action	1997-1998
LMR Park and Cemetery Area – Investigation and Engineering Evaluation/Cost Analysis	1998-1999
LMR Park and Cemetery – Removal Action Administrative Order by Consent and Statement of Work	2001
LMR Park and Cemetery – Work Plan for the LMR Time Critical Removal Action	2001
LMR Park and Cemetery –Time Critical Removal Action	2001
LMR Downstream Area – Final Work Plan for the Remedial Investigation and Feasibility Study	2002
LMR Downstream Area –Remedial Investigation Field Work	2002
LMR Downstream Area –Baseline Risk Assessment	2004
LMR Downstream Area –Remedial Investigation Report	2004
LMR Downstream Area –Feasibility Study Report	2004
Record of Decision for LMR Remedial Action	2004
LMR Downstream Area –Remedial Design – Administrative Order on Consent	2004
LMR Remedial Action – Unilateral Administrative Order	2005
LMR Downstream Area – Final Remedial Design Report	2005
LMR Downstream Area –Remedial Action Field Work	2005-2008
Demobilization from Remedial Action	2008
Remedial Action Corrections Period	2009
Remedial Activities Completion	2009
Final Remedial Action Inspection	2009
Preliminary Close Out Report	2010
Remedial Action Report	2010
Operation and Maintenance Plan	2010

Table 2. Remediation activities at the Little Mississinewa River Site (U.S. EPA, 2010)

Action	Responsible Party	Year
Remediated storm water retention basin	Viacom	1989
Excavation	UTAS	1998
Stream channel restoration	UTAS	1998
Addressed residual soils and sediment	Viacom	2001

Sediment removal in channel and in floodplain	Viacom and UTAS	2001-2002
Sediment removal in channel and in floodplain	UTAS	2005-2009

In 2010, the first five-year review report for the Little Mississinewa River site was completed (U.S. EPA 2010). The remedial actions implemented are considered protective of human health and the environment in the short term and are expected to be protective in the long term. All exposure pathways that could result in unacceptable risks to humans have been controlled (U.S. EPA 2013). However, in order for the remedy to be protective in the long term, fish tissue data needs to show that PCB concentrations in fish tissue are decreasing. The second five-year review was scheduled to be completed in 2015, but is not yet available (U.S. EPA 2013).

Study Purpose

The purpose of this report is to examine spatial and temporal trends in the PCB concentrations (1984-2013) measured in fish tissue samples from the Little Mississinewa and Mississinewa rivers and the Mississinewa Reservoir by IDEM OWQ, and discuss how these concentrations relate to human health guidelines for fish consumption and water quality assessments for impairments of the fishable designated beneficial aquatic life use.

Methods

Fish tissue samples were collected intermittently from 1984 to 2013 from selected sites on the Little Mississinewa River and the main stem Mississinewa River including Mississinewa Reservoir (Figure 1) for PCB concentration determinations by the IDEM OWQ. In most cases individual samples consisted of several to many fish of the same species and size class pooled into respective composite samples (Tables 3, 4, and 5). The sample preparation types included skin-off fillets (Ictaluridae species), skin-on, scaleless fillets, and whole fish samples.

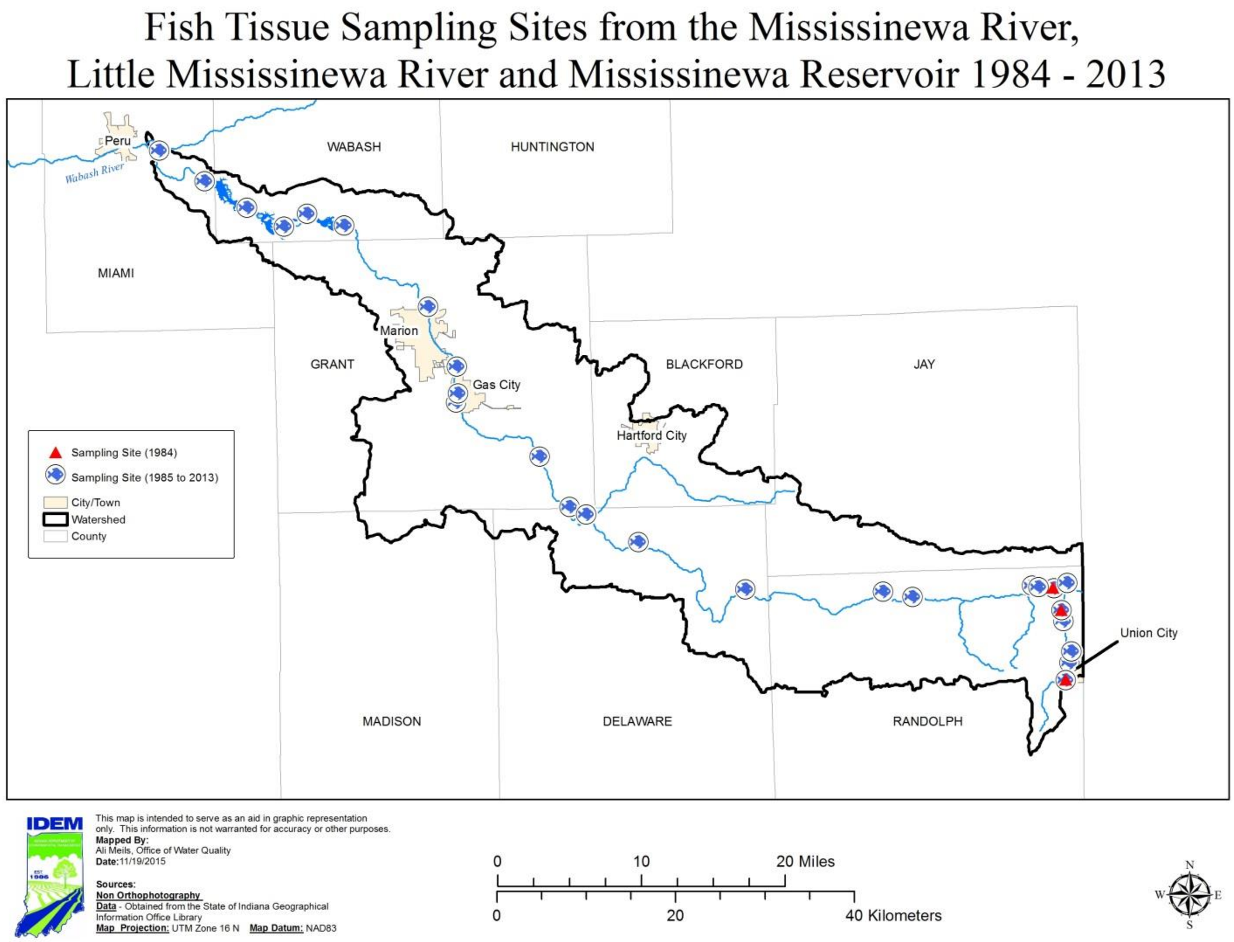

Figure 1. Fish tissue collection sites in the Little Mississinewa and Mississinewa rivers from 1984 to 2013.

PCB concentrations were determined by U.S. EPA analytical method 8082 (U.S. EPA 2007). PCBs accumulate in the fat of fish. The results were therefore lipid normalized to allow for comparison between the different preparation types, species, years and locations; and to assess the temporal and spatial trends of PCBs in the Little Mississinewa and Mississinewa rivers. Analytical results reported as less than the detection limit were censored by dividing the reporting limit by the square root of two (Croghan 2008). The Mann-Kendall (M-K) test was employed to test for statistical significance of the temporal trends (R Core Team 2015; McLeod 2011). The M-K is a non-parametric statistical test to assess if there is a monotonic upward or downward trend of PCBs in the fish over time.

Results

Across this period a total of 187 composite samples (Tables 3, 4 and 5) were analyzed for total PCBs by the IDEM OWQ (and including ISBH samples from 1984). The samples collected included species from the following families; *Centrarchidae, Ictaluridae, Cyprinidae, Catostomidae, Percidae, Sciaenidae*, and *Moronidae*. Of the

187 samples analyzed for PCBs, 14% of the samples results were below the laboratory reporting limit. In 1988 there were two samples collected from the Mississinewa River that were below the detection limit (50 µg/kg wet weight (ww)). Both of the samples were located in Grant County at least 60 river miles downstream of the contamination source. Both samples were comprised of panfish (White Crappie and Longear Sunfish) which typically have smaller fat reserves, where PCBs accumulate. Samples with PCB concentrations below the detection limit (12.5 – 29.2 µg/kg ww) were not collected again until the 2008 and 2013 sampling events. The samples were comprised of panfish (Bluegill, White Crappie, Green Sunfish, Rock Bass, and Longear Sunfish), as well as, top predators (Largemouth Bass and Smallmouth Bass) and fish with higher fat reserves (Bigmouth Buffalo and Common Carp).

Table 3. Fish tissue PCB concentrations from samples collected from the Mississinewa River

Date	County	Location	Species	Fish per Sample	Prep Code*	Mean Weight (g)	Mean Length (mm)	Total PCB (µg/kg ww)
19-Aug-03	Delaware	C.R. 375W @ Wheeling, IN	Rock Bass	1	3	220.0	211.0	13.4
19-Aug-03	Delaware	C.R. 375W @ Wheeling, IN	Largemouth Bass	1	3	395.0	298.0	31.8
19-Aug-03	Delaware	C.R. 375W @ Wheeling, IN	Common Carp	3	3	1653.7	481.3	164.0
19-Aug-03	Delaware	C.R. 375W @ Wheeling, IN	Black Redhorse	3	3	498.3	383.7	283.0
19-Aug-03	Delaware	C.R. 375W @ Wheeling, IN	Channel Catfish	3	2	1625.3	538.7	313.0
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Common Carp	5	3	1837.0	506.0	105.0
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Channel Catfish	3	2	1086.7	481.3	158.0
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Channel Catfish	2	2	2551.5	603.0	217.0
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Golden Redhorse	6	3	501.0	337.7	< 19
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Largemouth Bass	1	3	794.0	352.0	< 19
04-Aug-08	Delaware	C.R. 375W @ Wheeling, IN	Smallmouth Bass	1	3	255.0	256.0	< 29.2
17-Jun-13	Delaware	C.R. 375W @ Wheeling, IN	Smallmouth Bass	3	3	402.0	296.3	12.8
17-Jun-13	Delaware	C.R. 375W @ Wheeling, IN	Smallmouth Bass	1	3	1024.0	401.0	< 12.5
17-Jun-13	Delaware	C.R. 375W @ Wheeling, IN	White Crappie	6	3	49.2	163.7	< 12.5
22-Nov-88	Randolph	C.R. 700E	creek chub	5	1	26.0	141.0	760.0
22-Nov-88	Randolph	C.R. 700E	green sunfish	8	1	14.0	99.0	3100.0
10-Sep-98	Randolph	C.R. 700E	White Crappie	3	3	239.0	253.0	360.0
10-Sep-98	Randolph	C.R. 700E	White Crappie	3	3	91.0	199.0	360.0
10-Sep-98	Randolph	C.R. 700E	Common Carp	3	3	1296.0	452.0	2800.0
10-Sep-98	Randolph	C.R. 700E	Channel Catfish	3	2	1278.0	488.0	6300.0
21-Jul-98	Grant	CR 450 W	Common Carp	2	3	1418.0	477.0	370.0
31-Jul-08	Randolph	CR 600 E	Largemouth Bass	1	3	344.0	295.0	118.0
31-Jul-08	Randolph	CR 600 E	Golden Redhorse	4	3	402.3	329.0	359.0
31-Jul-08	Randolph	CR 600 E	Rock Bass	6	3	78.7	157.2	542.0
31-Jul-08	Randolph	CR 600 E	Common Carp	3	3	1984.3	528.0	878.0
31-Jul-08	Randolph	CR 600 E	Channel Catfish	1	2	2438.0	625.0	7920.0

Table 3 continued

02-Jul-13	Randolph	CR 600 E	Common Carp	2	3	558.0	327.0	85.4
02-Jul-13	Randolph	CR 600 E	Freshwater Drum	4	3	291.0	281.0	123.0
02-Jul-13	Randolph	CR 600 E	White Crappie	2	3	312.0	264.5	147.0
02-Jul-13	Randolph	CR 600 E	Common Carp	2	3	2847.0	565.0	273.0
02-Jul-13	Randolph	CR 600 E	Channel Catfish	1	2	1788.0	538.0	523.0
05-Aug-98	Randolph	CR 900 N	Common Carp	2	3	1659.0	499.0	2700.0
28-Sep-88	Delaware	D/S Albany, IN @ Dowden Rd.	Bluegill	5	3	54.0	137.0	50.0
28-Sep-88	Delaware	D/S Albany, IN @ Dowden Rd.	Green Sunfish	5	1	35.0	116.0	180.0
28-Sep-88	Delaware	D/S Albany, IN @ Dowden Rd.	Common Carp	4	3	1219.0	439.0	380.0
8-Nov-84	Randolph	d/s Little Mississinewa River @ C.R. 700E	Common Carp	1	1	780.0	395.0	5166.0
29-Sep-88	Randolph	D/S RIDGEVILLE,CR800N & 500W	Longear Sunfish	7	1	29.0	112.0	470.0
29-Sep-88	Randolph	D/S RIDGEVILLE,CR800N & 500W	Common Carp	5	3	1009.0	462.0	1200.0
29-Sep-88	Randolph	D/S RIDGEVILLE,CR800N & 500W	Channel Catfish	3	2	614.0	425.0	2400.0
18-Aug-93	Randolph	D/S RIDGEVILLE,CR800N & 500W	Channel Catfish	5	2	875.0	448.0	1000.0
18-Aug-93	Randolph	D/S RIDGEVILLE,CR800N & 500W	Common Carp	5	3	2486.0	566.0	3100.0
19-Aug-98	Grant	First St	Common Carp	2	3	570.0	344.0	240.0
19-Aug-98	Grant	First St	Longear Sunfish	6	1	24.0	107.0	540.0
17-Sep-98	Miami	Frances Slocum Trail	Common Carp	3	3	1701.0	493.0	180.0
17-Sep-98	Miami	Frances Slocum Trail	Longear Sunfish	2	1	70.0	151.0	200.0
27-Sep-88	Delaware	N Walnut St, West of Eaton	Rock Bass	3	3	101.0	176.0	86.0
27-Sep-88	Delaware	N Walnut St, West of Eaton	Bluegill	4	3	93.0	170.0	95.0
27-Sep-88	Delaware	N Walnut St, West of Eaton	Common Carp	5	3	1559.0	486.0	1000.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Rock Bass	6	3	154.8	189.7	177.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Smallmouth Bass	3	3	613.7	349.0	273.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Smallmouth Bass	4	3	165.5	228.0	379.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Golden Redhorse	5	3	213.6	266.8	441.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Common Carp	3	3	1587.7	484.0	1600.0
19-Aug-03	Randolph	S.R. 28, Ridgeville, IN	Common Carp	3	3	2721.3	572.0	4020.0
26-Sep-88	Grant	SR 22 Bridge, Jonesboro, IN	Channel Catfish	2	2	350.0	347.0	150.0
26-Sep-88	Grant	SR 22 Bridge, Jonesboro, IN	Common Carp	2	3	1447.0	469.0	550.0

Table 3 continued

26-Sep-88	Grant	SR 22 Bridge, Jonesboro, IN	White Crappie	3	3	210.0	247.0	<50
31-Jul-08	Randolph	SR 28 @ Ridgeville, IN	Rock Bass	9	3	106.7	173.0	20.4
31-Jul-08	Randolph	SR 28 @ Ridgeville, IN	Rock Bass	8	3	178.9	204.8	48.8
31-Jul-08	Randolph	SR 28 @ Ridgeville, IN	Smallmouth Bass	4	3	470.5	327.8	94.7
31-Jul-08	Randolph	SR 28 @ Ridgeville, IN	White Sucker	5	3	299.4	299.4	120.0
31-Jul-08	Randolph	SR 28 @ Ridgeville, IN	Smallmouth Bass	2	3	166.0	234.5	148.0
02-Jul-13	Randolph	SR 28 @ Ridgeville, IN	Longear Sunfish	7	3	40.0	117.1	36.9
02-Jul-13	Randolph	SR 28 @ Ridgeville, IN	Common Carp	3	3	980.0	410.3	119.0
02-Jul-13	Randolph	SR 28 @ Ridgeville, IN	Common Carp	2	3	1527.0	455.0	157.0
02-Jul-13	Randolph	SR 28 @ Ridgeville, IN	Rock Bass	6	3	152.7	189.7	< 12.5
02-Jul-13	Randolph	SR 28 @ Ridgeville, IN	Rock Bass	2	3	253.0	226.5	< 12.5
25-Aug-88	Grant	SR 9/37, N of Marion, D/S of STP	Channel Catfish	2	2	136.0	272.0	190.0
25-Aug-88	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	4	3	744.0	381.0	410.0
25-Aug-88	Grant	SR 9/37, N of Marion, D/S of STP	Longear Sunfish	15	3	38.0	110.0	<50
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Largemouth Bass	2	3	398.0	285.0	87.4
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Smallmouth Bass	2	3	301.0	270.5	129.0
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Silver Redhorse	5	3	770.4	407.8	287.0
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Flathead Catfish	3	2	899.3	410.0	324.0
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Quillback	3	3	562.7	358.3	438.0
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	3	3	2438.0	553.0	751.0
20-Aug-03	Grant	SR 9/37, N of Marion, D/S of STP	Flathead Catfish	2	2	2069.5	534.5	803.0
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Smallmouth Bass	3	3	372.7	292.7	48.1
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	4	3	580.0	337.8	49.5
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Freshwater Drum	3	3	510.0	346.0	52.2
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Flathead Catfish	1	2	340.0	410.0	76.2
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Freshwater Drum	1	3	1871.0	520.0	139.0
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Flathead Catfish	1	2	3118.0	623.0	226.0
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	3	3	1493.0	502.7	248.0
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Channel Catfish	1	2	964.0	462.0	348.0
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	Largemouth Bass	1	3	907.0	380.0	< 19
04-Aug-08	Grant	SR 9/37, N of Marion, D/S of STP	White Crappie	5	3	117.2	234.8	< 19

Table 3 continued

17-Jul-13	Grant	SR 9/37, N of Marion, D/S of STP	Longear Sunfish	13	3	50.8	128.5	17.5
17-Jul-13	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	3	3	726.0	381.3	68.1
17-Jul-13	Grant	SR 9/37, N of Marion, D/S of STP	Common Carp	2	3	1223.0	448.5	81.6
17-Jul-13	Grant	SR 9/37, N of Marion, D/S of STP	Flathead Catfish	1	2	6126.0	742.0	219.0
17-Jul-13	Grant	SR 9/37, N of Marion, D/S of STP	White Crappie	12	3	48.0	170.8	< 12.5
17-Aug-93	Randolph	U/S LITTLE MISS, C.R. 800E	Common Carp	2	3	2583.0	582.0	1300.0
17-Aug-93	Randolph	U/S LITTLE MISS, C.R. 800E	Channel Catfish	3	2	1032.0	471.0	5800.0
18-Aug-03	Randolph	U/S LITTLE MISS, C.R. 800E	Longear Sunfish	9	1	18.8	90.1	80.4
18-Aug-03	Randolph	U/S LITTLE MISS, C.R. 800E	White Sucker	7	3	131.9	230.6	434.0
18-Aug-03	Randolph	U/S LITTLE MISS, C.R. 800E	White Sucker	11	1	55.5	172.6	1210.0
18-Aug-03	Randolph	U/S LITTLE MISS, C.R. 800E	Striped Shiner	10	1	26.2	126.3	1770.0
18-Aug-03	Randolph	U/S LITTLE MISS, C.R. 800E	Smallmouth Bass	1	3	226.0	239.0	2070.0
30-Jul-08	Randolph	U/S LITTLE MISS, C.R. 800E	Green Sunfish	6	1	47.5	129.2	62.3
30-Jul-08	Randolph	U/S LITTLE MISS, C.R. 800E	White Sucker	5	3	155.0	248.8	122.0
30-Jul-08	Randolph	U/S LITTLE MISS, C.R. 800E	Smallmouth Bass	2	3	250.0	250.0	252.0
30-Jul-08	Randolph	U/S LITTLE MISS, C.R. 800E	Common Carp	5	3	1587.6	479.0	482.0
30-Jul-08	Randolph	U/S LITTLE MISS, C.R. 800E	Common Carp	6	3	277.0	265.5	< 19
02-Jul-13	Randolph	U/S LITTLE MISS, C.R. 800E	White Sucker	3	3	104.7	214.7	14.7
02-Jul-13	Randolph	U/S LITTLE MISS, C.R. 800E	Longear Sunfish	11	3	43.3	121.3	39.4
02-Jul-13	Randolph	U/S LITTLE MISS, C.R. 800E	Green Sunfish	2	3	121.0	179.5	46.7
02-Jul-13	Randolph	U/S LITTLE MISS, C.R. 800E	Green Sunfish	4	3	57.5	138.3	< 12.5
24-Aug-88	Grant	U/S Marion, IN and D/S Gas City, IN	Largemouth Bass	2	3	207.0	247.0	130.0
24-Aug-88	Grant	U/S Marion, IN and D/S Gas City, IN	Channel Catfish	6	2	257.0	321.0	210.0
24-Aug-88	Grant	U/S Marion, IN and D/S Gas City, IN	Common Carp	4	3	1318.0	469.0	1100.0
19-Aug-03	Grant	W of SR 26 at approx. 825 S	Longear Sunfish	6	1	54.5	129.3	202.0
19-Aug-03	Grant	W of SR 26 at approx. 825 S	Common Carp	3	3	2409.7	537.7	226.0
19-Aug-03	Grant	W of SR 26 at approx. 825 S	Channel Catfish	3	2	2126.3	602.3	244.0

*Prep Codes: The preparation type of the sample; 1 = whole fish, 2= skin-off fillets, 3=skin-on fillets/scaleless.

Table 4. Fish tissue PCB concentrations from samples collected from the Little Mississinewa River

Date	County	Location	Species	Fish per Sample	Prep Code*	Mean Weight (g)	Mean Length (mm)	Total PCB (µg/kg ww)
04-Aug-98	Randolph	C.R. 700N	Creek Chub	8	1	46.0	162.0	10000
04-Aug-98	Randolph	C.R. 700N	Yellow Bullhead	7	1	83.0	172.0	11000
30-Jun-03	Randolph	CR N 800 E	White Sucker	3	3	208.0	257.3	3830
30-Jun-03	Randolph	CR N 800 E	Creek Chub	6	1	30.8	140.3	11800
7-Nov-84	Randolph	D/S UNION CITY STP,CR700N	Creek Chub	12	1	36.0	143.0	11264
21-Nov-88	Randolph	D/S UNION CITY STP,CR700N	Creek Chub	5	1	44.0	162.0	4100
21-Nov-88	Randolph	D/S UNION CITY STP,CR700N	Green Sunfish	4	1	20.0	98.0	13000
17-Aug-93	Randolph	D/S UNION CITY STP,CR700N	Creek Chub	6	1	114.0	215.0	23000
28-Jul-03	Randolph	D/S UNION CITY STP,CR700N	White Sucker	6	3	130.3	231.3	6530
28-Jul-03	Randolph	D/S UNION CITY STP,CR700N	Creek Chub	10	1	74.7	187.0	12100
28-Jul-03	Randolph	D/S UNION CITY STP,CR700N	White Sucker	8	1	60.6	180.8	23200
30-Jul-08	Randolph	D/S UNION CITY STP,CR700N	Rock Bass	6	3	103.0	170.7	1190
30-Jul-08	Randolph	D/S UNION CITY STP,CR700N	White Sucker	9	3	98.2	220.9	1200
30-Jul-08	Randolph	D/S UNION CITY STP,CR700N	Smallmouth Bass	4	3	267.0	270.8	1410
30-Jul-08	Randolph	D/S UNION CITY STP,CR700N	Creek Chub	15	1	63.0	171.9	2990
30-Jul-08	Randolph	D/S UNION CITY STP,CR700N	Longear Sunfish	13	1	35.0	112.2	3880
17-Jun-13	Randolph	D/S UNION CITY STP,CR700N	White Sucker	5	3	176.0	247.6	950
17-Jun-13	Randolph	D/S UNION CITY STP,CR700N	Yellow Bullhead	3	1	62.0	149.3	1130
17-Jun-13	Randolph	D/S UNION CITY STP,CR700N	Longear Sunfish	11	1	32.0	106.2	1140
17-Jun-13	Randolph	D/S UNION CITY STP,CR700N	Rock Bass	5	1	27.6	106.8	1490
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	White Sucker	6	3	242.7	275.7	10400
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	Common Carp	2	3	401.5	284.0	15300
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	Common Carp	1	3	2041.0	535.0	16100
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	Longear Sunfish	4	1	35.0	111.5	24700
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	Creek Chub	8	1	44.8	152.8	25500
28-Jul-03	Randolph	D/S Union City, IN @ C.R. 400N	White Sucker	10	1	70.6	186.8	37500
30-Jul-08	Randolph	D/S Union City, IN @ C.R. 400N	White Sucker	9	1	59.6	173.6	2540
30-Jul-08	Randolph	D/S Union City, IN @ C.R. 400N	Creek Chub	8	1	52.6	157.9	3030

Table 4 continued

30-Jul-08	Randolph	D/S Union City, IN @ C.R. 400N	Bluegill	7	1	65.4	143.9	4180
30-Jul-08	Randolph	D/S Union City, IN @ C.R. 400N	Yellow Bullhead	5	1	92.8	180.0	6390
30-Jul-08	Randolph	D/S Union City, IN @ C.R. 400N	Longear Sunfish	13	1	36.1	110.9	6620
17-Jun-13	Randolph	D/S Union City, IN @ C.R. 400N	Common Carp	1	3	1720.0	480.0	266
17-Jun-13	Randolph	D/S Union City, IN @ C.R. 400N	Central Stoneroller	12	1	17.2	110.0	1040
17-Jun-13	Randolph	D/S Union City, IN @ C.R. 400N	Yellow Bullhead	6	1	96.3	176.7	1180
17-Jun-13	Randolph	D/S Union City, IN @ C.R. 400N	Creek Chub	10	1	22.8	119.9	1450
04-Aug-98	Randolph	D/S UNION CITY, IN STP OUTFALL	White Sucker	5	3	157.0	242.0	19000
7-Nov-84	Randolph	u/s Sheller Globe, Union City, IN	Creek Chub	12	1	50.0	165.0	11861
21-Nov-88	Randolph	U/S UNION CITY,WESTINGHOUSE RD	Creek Chub	3	1	17.0	113.0	25000
17-Aug-93	Randolph	U/S UNION CITY,WESTINGHOUSE RD	Creek Chub	15	1	49.0	159.0	15000
05-Aug-98	Randolph	UNION CITY, WESTINGHOUSE RD.	Creek Chub	10	1	32.0	141.0	11000
05-Aug-98	Randolph	UNION CITY, WESTINGHOUSE RD.	White Sucker	3	1	60.0	174.0	12000

*Prep Codes: The preparation type of the sample; 1 = whole fish, 2= skin-off fillets, 3=skin-on fillets/scaleless.

Table 5. Fish tissue PCB concentrations from samples collected from the Mississinewa Reservoir

Date	County	Location	Species	Fish per Sample	Prep Code*	Mean Weight (g)	Mean Length (mm)	Total PCB (µg/kg ww)
04-Aug-98	Miami	DAM END	Walleye	2	3	289.0	323.0	17
04-Aug-98	Miami	DAM END	White Crappie	3	3	NA	267.0	22
04-Aug-98	Miami	DAM END	Smallmouth Bass	1	3	516.0	338.0	29
04-Aug-98	Miami	DAM END	Channel Catfish	3	2	NA	443.0	190
14-Oct-08	Miami	DAM END	Common Carp	3	3	1701.0	515.7	58.3
14-Oct-08	Miami	DAM END	Channel Catfish	3	2	1833.3	565.0	220
14-Oct-08	Miami	DAM END	Bluegill	6	3	91.8	164.0	< 19
14-Oct-08	Miami	DAM END	Largemouth Bass	5	3	1134.2	412.2	< 19
14-Oct-08	Miami	DAM END	Largemouth Bass	5	3	611.2	346.4	< 19
04-Sep-13	Miami	DAM END	Common Carp	3	3	1932.7	540.0	61.9

Table 5 continued

04-Sep-13	Miami	DAM END	Bluegill	6	3	70.0	154.3	< 12.5
04-Sep-13	Miami	DAM END	Largemouth Bass	3	3	336.7	290.0	< 12.5
04-Sep-13	Miami	DAM END	Longear Sunfish	6	3	58.3	135.3	< 12.5
14-Oct-08	Wabash	Pearson Mill Public Access	River Carpsucker	5	3	640.4	371.8	125
14-Oct-08	Wabash	Pearson Mill Public Access	Common Carp	4	3	1757.8	503.8	176
14-Oct-08	Wabash	Pearson Mill Public Access	Bigmouth Buffalo	2	3	1587.5	481.5	< 19
14-Oct-08	Wabash	Pearson Mill Public Access	Bluegill	5	3	111.0	173.8	< 19
14-Oct-08	Wabash	Pearson Mill Public Access	Largemouth Bass	5	3	504.4	335.8	< 19
14-Oct-08	Wabash	Pearson Mill Public Access	Largemouth Bass	4	3	204.0	243.3	< 19
06-Oct-04	Wabash	Red Ridge SRA	Largemouth Bass	5	3	834.2	379.0	55.3
06-Oct-04	Wabash	Red Ridge SRA	Freshwater Drum	2	3	995.5	432.0	76.1
06-Oct-04	Wabash	Red Ridge SRA	White Bass	6	3	253.8	266.0	111
06-Oct-04	Wabash	Red Ridge SRA	Common Carp	5	3	1576.0	484.4	120
06-Oct-04	Wabash	Red Ridge SRA	Largemouth Bass	5	3	639.2	342.0	126
16-Jul-85	Wabash	U/S LaFontaine	White Crappie	7	2	212.0	243.0	35
16-Jul-85	Wabash	U/S LaFontaine	Common Carp	3	2	452.0	320.0	70
24-Aug-98	Wabash	UPPER END	Largemouth Bass	3	3	419.0	309.0	68
24-Aug-98	Wabash	UPPER END	Largemouth Bass	3	3	901.0	391.0	110
04-Sep-13	Wabash	UPPER END	Common Carp	3	3	1592.7	493.7	57.3
04-Sep-13	Wabash	UPPER END	Bluegill	7	3	115.4	175.1	< 12.5
04-Sep-13	Wabash	UPPER END	Freshwater Drum	1	3	862.0	397.0	< 12.5
04-Sep-13	Wabash	UPPER END	Largemouth Bass	2	3	606.0	344.0	< 12.5

*Prep Codes: The preparation type of the sample; 1 = whole fish, 2= skin-off fillets, 3=skin-on fillets/scaleless.

The M-K assesses whether a time-ordered data set exhibits an increasing or decreasing trend. Data collections spanned the time period from 1984 to 2013 at a number of site locations and at different time intervals. The M-K was run on all data collectively, data from 1984 to 2003, data from 2003 to 2013, and the data in the Little Mississinewa River only since that was the known source of the contamination. Based on the 2-sided P-values, the null hypothesis was accepted in the time series from 1984 to 2003 indicating there was no monotonic trend in the data (Table 6). The remaining three tests accepted the alternative hypothesis that there is a significant trend in the time series (p-value < 0.05). All time series showed a downward trend in the Tau test result, with the Little Mississinewa River samples having the greatest strength of association.

Table 6. Mann-Kendall Trend Test Results.

M-K Outputs	1984 - 2013	1984 - 2003	2003 - 2013	LMR# Only (1984 – 2013)
2-Sided P-Value	**6.27e-12**	0.546	**4.99e-13**	**2.26e-06**
Tau	-0.338	-0.043	-0.425	-0.515
Score	-5883	-180	-3674	-422
Denominator	17390	4186	8645	820

*If p-value is < 0.05 then the null hypothesis is rejected.

Little Mississinewa River

The majority of the remedial work was done between 2005 and 2009, which can be seen in the reduction of PCB concentrations in samples (Figures 2, 3, 5, and 7). The PCB concentrations remained steady with no significant changes in fish concentrations from 1984 through 2003 (Table 6, Figure 4). A strong downward trend is observed using only the Little Mississinewa data (Figure 5). The river was further divided into six stream segments (Figure 6) to illustrate any temporal distributional patterns in PCB concentrations. Segment 1 is the Mississinewa River upstream of the confluence with the Little Mississinewa River and represents background concentrations of known PCBs expected to be found in the river. Segment 2 is the Little Mississinewa River which has been the primary source of the PCB contamination in the watershed. Figure 7 illustrates how the PCB concentrations are diffused downstream as you travel through the basin. Common family and genus samples were grouped together in the figures to observe differences in PCB concentrations across species that tend to have higher lipid percentages.

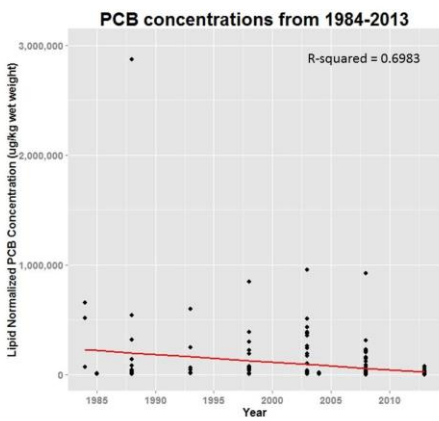

Figure 2. PCB Concentrations in Fish Tissue from the Little Mississinewa and Mississinewa Rivers, 1984 to 2013.

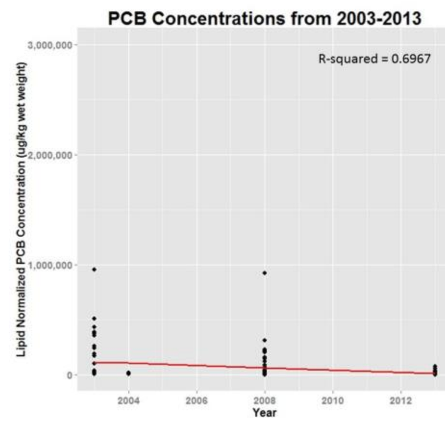

Figure 3. PCB Concentrations in Fish Tissue from the Little Mississinewa and Mississinewa Rivers, 2003 to 2013.

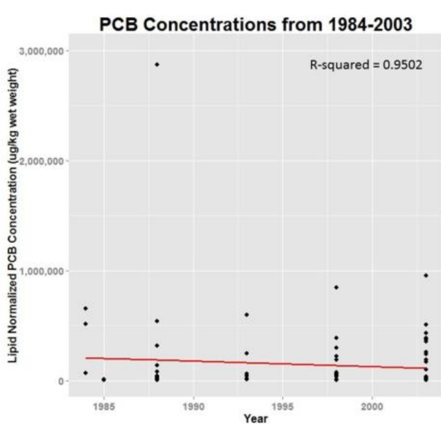

Figure 4. PCB Concentrations in Fish Tissue from the Little Mississinewa and Mississinewa Rivers, 1984 to 2003.

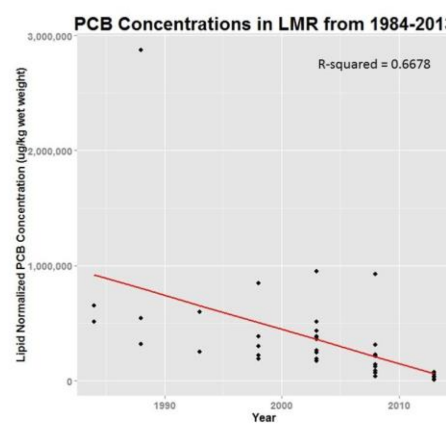

Figure 5. PCB Concentrations in Fish Tissue from the Little Mississinewa River, 1984 to 2013.

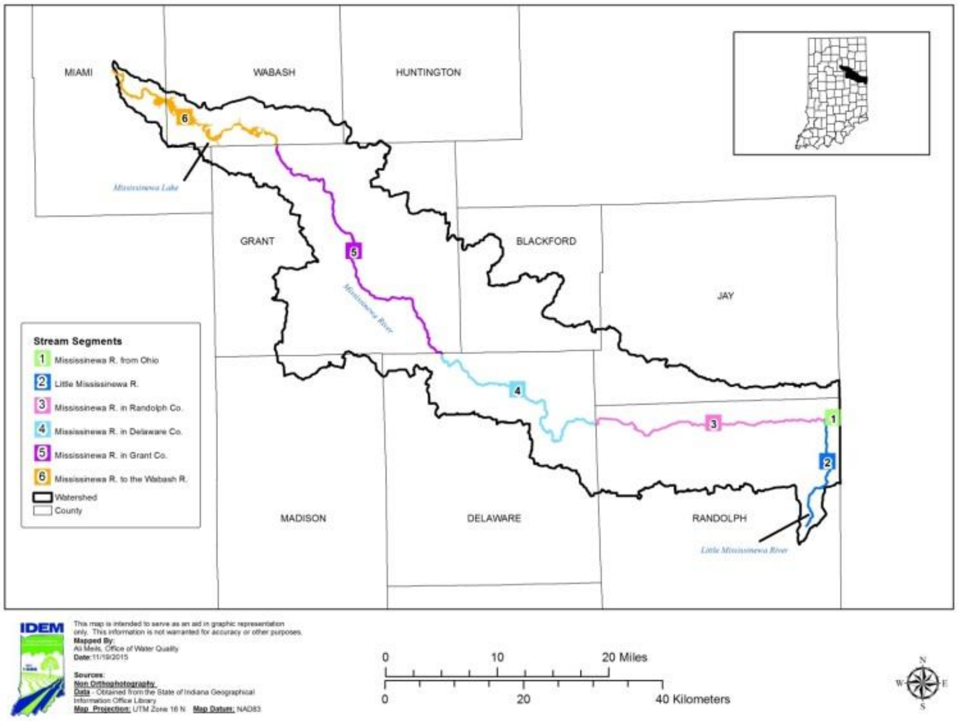

Figure 6. Stream segments along the Mississinewa and Little Mississinewa Rivers and the Mississinewa Reservoir used in the analysis of PCB trends in Figure 7.

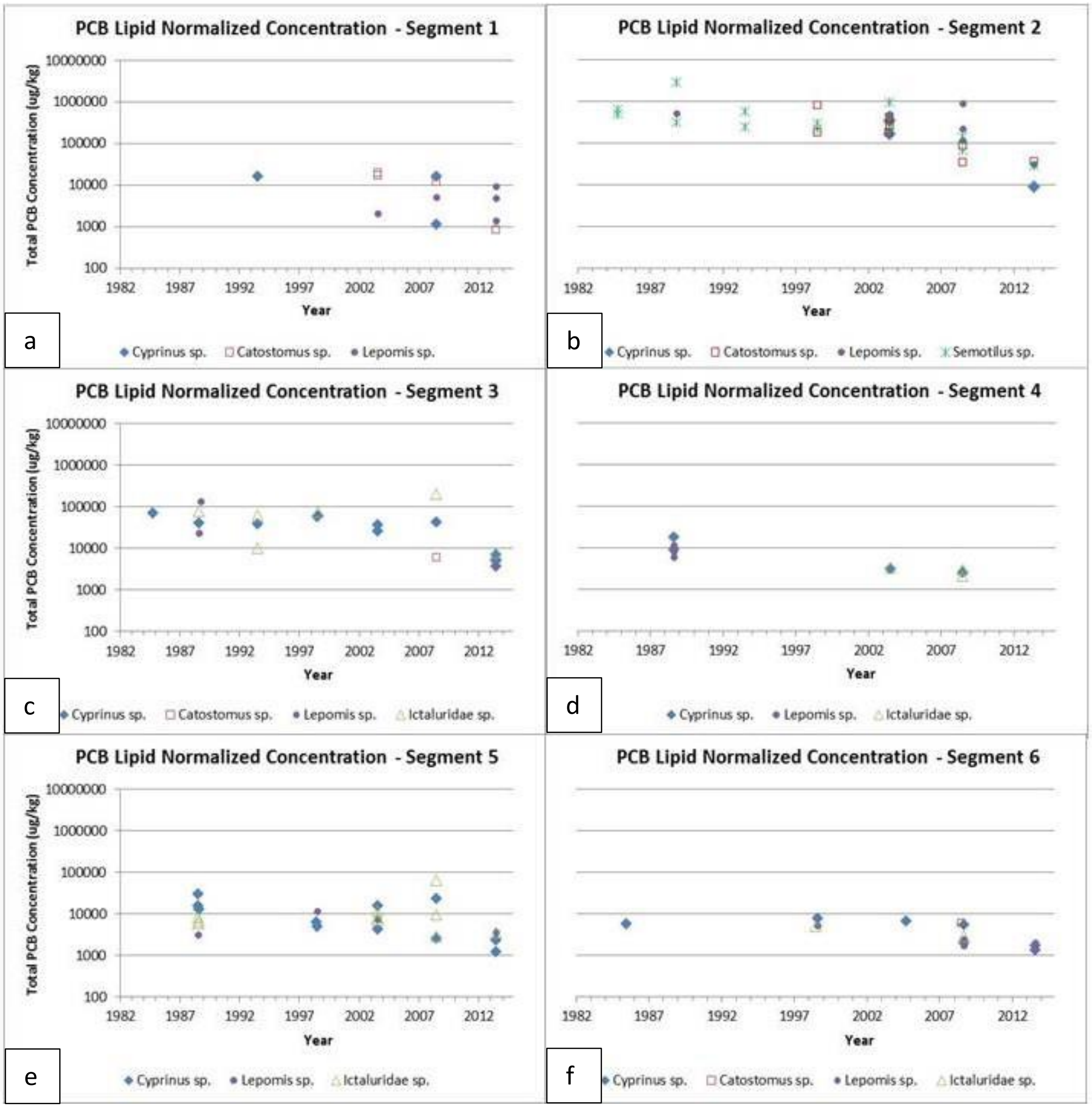

Figure 7 (a, b, c, d, e, and f). Temporal Trends in PCB Concentrations in Fish Tissue from the Little Mississinewa and Mississinewa Rivers and the Mississinewa Reservoir.

The median concentration of all samples collected from a site was used to map the changes in PCB concentrations through time and location (Figures 8 and 9). These data were mapped on a log scale since the results spanned several orders of magnitude through the years. In 2003, the highest PCB concentration was 37,500 µg/kg ww. The PCB concentrations remained steady with no significant changes in fish concentrations from 1984 through 1998 (Figure 8). From 2003 to 2013, reductions in PCB concentrations are observed from the source on the LMR and can be followed downstream along the mainstem Mississinewa River (Figure 5).

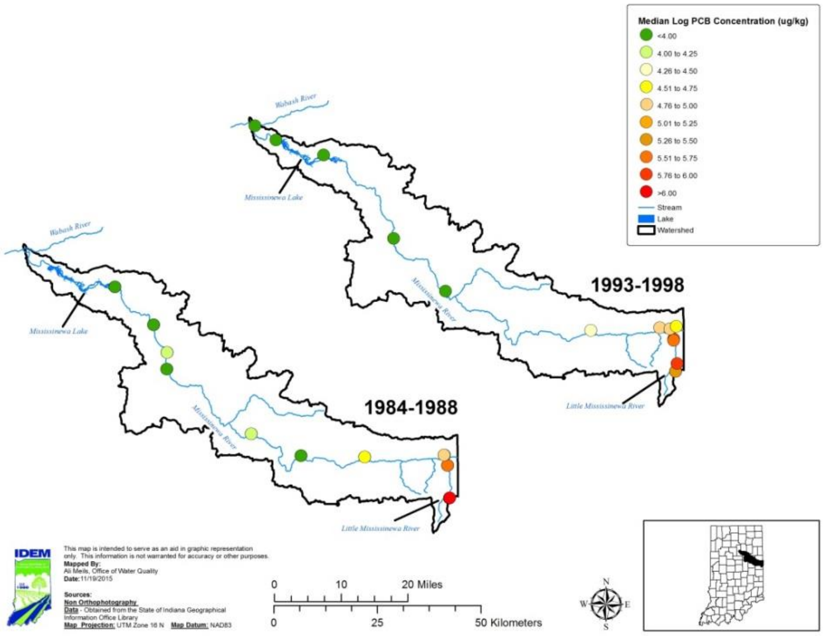

Figure 8. Median lipid normalized PCB concentrations in fish from the Little Mississinewa and Mississinewa Rivers and the Mississinewa Reservoir from 1984 to 1999.

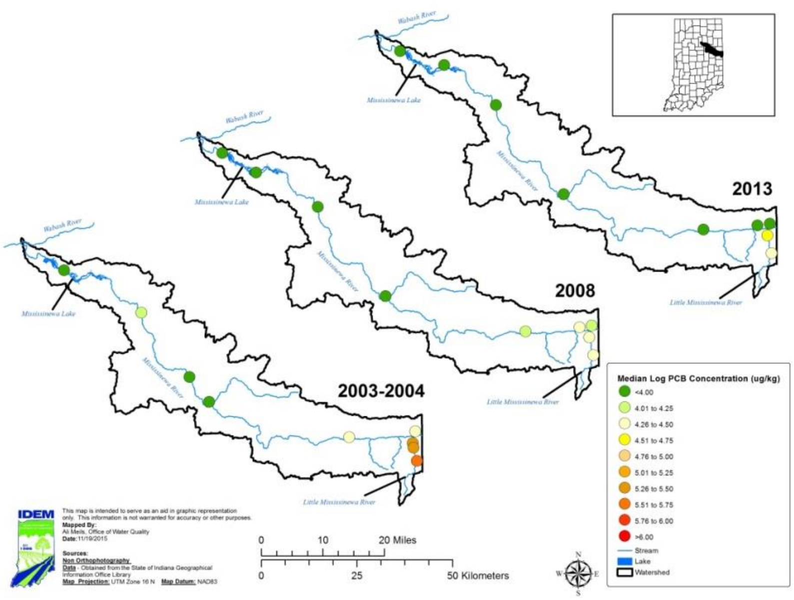

Figure 9. Median lipid normalized PCB concentrations in fish from the Little Mississinewa and Mississinewa rivers and the Mississinewa Reservoir from 2003 to 2013.

While there is evidence that PCB concentrations are decreasing in the fish tissues, from a human health perspective, the current Fish Consumption Advisory (FCA) recommends to not eat any fish from the Little Mississinewa River (ISDH 2015). The samples collected from the Little Mississinewa River in 2013 were below the Indiana FCA Group 5 benchmark (1877 µg/kg ww) (Figure 10 and Table 7) used for Indiana wild caught fish in consumption advice for scaleless, skin-on fillets. However, the levels of PCBs remain close to the Group 5 benchmark, and additional sampling is recommended before changing the consumption advisory information. The main stem of the Mississinewa River, including the Mississinewa Reservoir, has Fish Consumption Advisory recommendations from unlimited consumption (Group 1) to "Do Not Eat" (Group 5) for the general population due to PCBs depending on the species and the size classes of each species. IDEM is scheduled to resample the Little Mississinewa River and the Mississinewa River again in 2018. More information about the Indiana Fish Consumption Advisory can be found at http://www.in.gov/isdh/23650.htm.

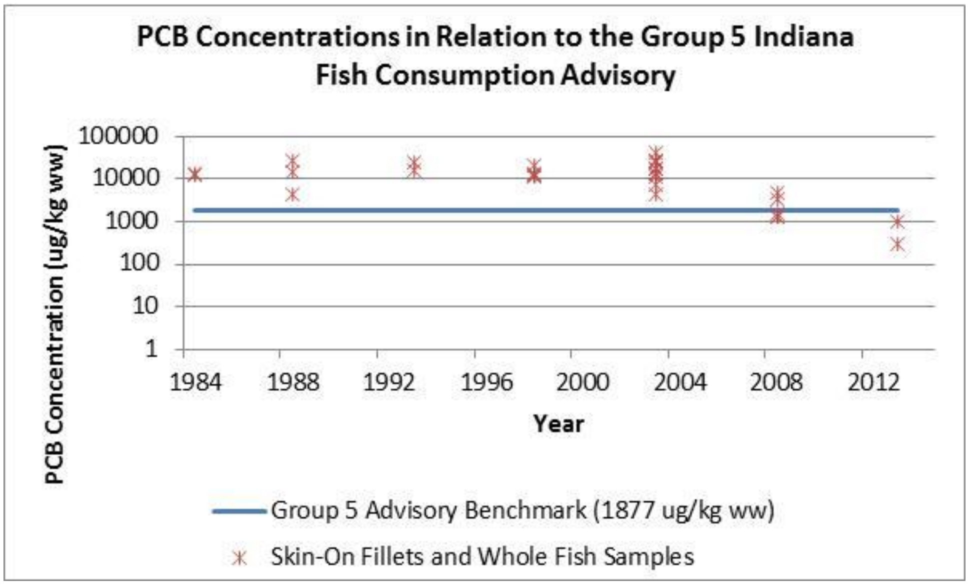

Figure 15. PCB concentrations in the Little Mississinewa River in relation to the Indiana Fish Consumption Advisory Group 5 (Do Not Eat) benchmark.

Table 7. Indiana Fish Consumption Advisory Groupings based on PCB concentrations.

Group	Skin-On Scaleless Fillets (µg/kg ww)	Skin-Off Fillets (µg/kg ww)
1	0 - 50.0	0 - 35.76
2	50.0 - 216.6	35.76 - 154.7
3	216.6 - 938.6	154.7 - 670.4
4	938.6 - 1877	670.4 - 1341
5	>1877	>1341

Conclusion

The PCB concentrations in fish tissue samples collected from the Little Mississinewa River and Mississinewa River remained steady with no significant trend line from 1984 to 2003. A downward trend is observed considering only the 2003, 2008 and 2013 data results across all stream segments. This decreasing trend has implications for designated beneficial aquatic life uses and fish consumption advisory information. Results from sampling conducted in 2013 indicated one stream reach along the Mississinewa River had fish tissue concentrations below the benchmark for the aquatic life use support classification. This portion of the Mississinewa River will be delisted from having a PCB impairment which will be reflected in the 2016 303(d) List of Impaired Waters. PCB concentrations in the 2013 Little Mississinewa samples were below the DO NOT EAT group 5 benchmark for the first time in 30 years, however, until additional sampling is conducted to verify that fish tissue samples are maintaining these levels, no fish consumption advisory information will be changed from the current Group 5 listing. The contamination was first identified in 1984 and no trend in PCB concentrations was observed through the 2003 sampling events. The bulk of the remediation work to abate PCBs was conducted from 2005 to 2008, and it is shown through the data that PCBs were continually impacting the stream until their removal from the contaminated sites. No downward trend appeared until the 2008 and 2013 sampling events, which were after the contaminated soils and sediments were removed from the sites. Once in the environment, PCBs persist for very long periods of time as they are not readily degraded. These data further support the necessity of remedial actions in relation to known PCB contaminated sites.

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